# SCaN the horizon: Space-based quantum communications and navigation.

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March 24, 2023

**QED-C, Chattanooga, Tennessee**

# Briefing Highlights & Main Take-Aways

- **A collaborative vision**
  - 5- and 10-year plans
  - Towards a ‘user-facility;’ **testbed** in LEO and 1 ground station
  - Then a **Quantum Mission** in MEO and 2 ground stations (**M2.0**)
  - Quantum-Comm **Engineering Center**
  - Quantum-Comm **Science Center**

- **Current activities**
  - technology development, pre-formulation studies and analyses
  - Metrology capability building
  - Partnership building
  - Blueprints for public-private partnerships for the two centers

- **Industry**
  - Use cases and applications;  Technology development; Engr./Science centers

# **About SCaN** (www.nasa.gov/scan)

- Through the near earth and deep space networks SCaN provides NASA science and exploration missions with all their RF communications and navigation capabilities
- Near earth network; for LEO and up to lunar missions, supported by a constellation of geosynchronous satellites for tracking/data relay
- Deep space network; continuous coverage via 3 ground stations, also radio telescopes
- SCaN is also responsible for **future capabilities**

ALASKA SATELLITE FACILITY (NEN)
Fairbanks, Alaska
NASA: We are SCaN - YouTube

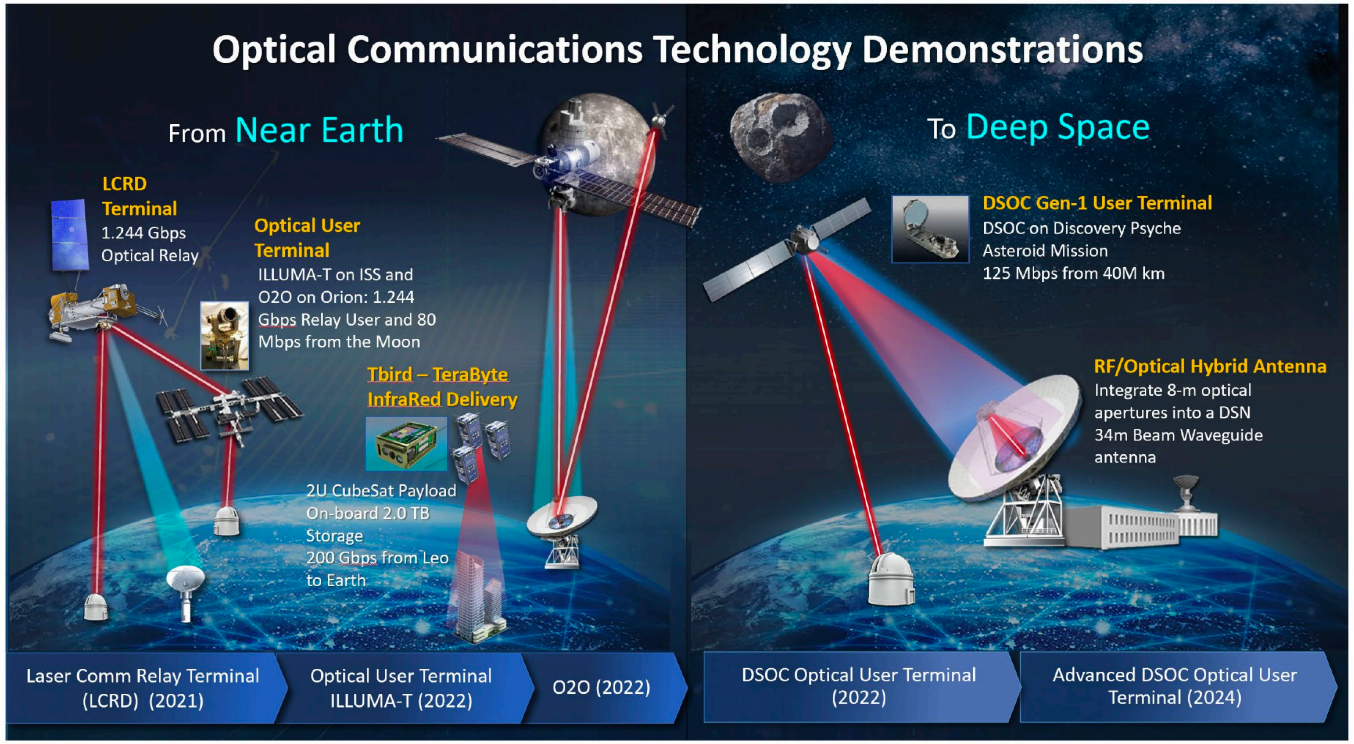
# SCaN's quantum strategy

- Leverage optical communications investments, experience, and accomplishments to build foundational capabilities, including a quantum testbed and metrology capability

- Develop and mature key (low TRL) for space-based and ground-based quantum communications and networking technologies

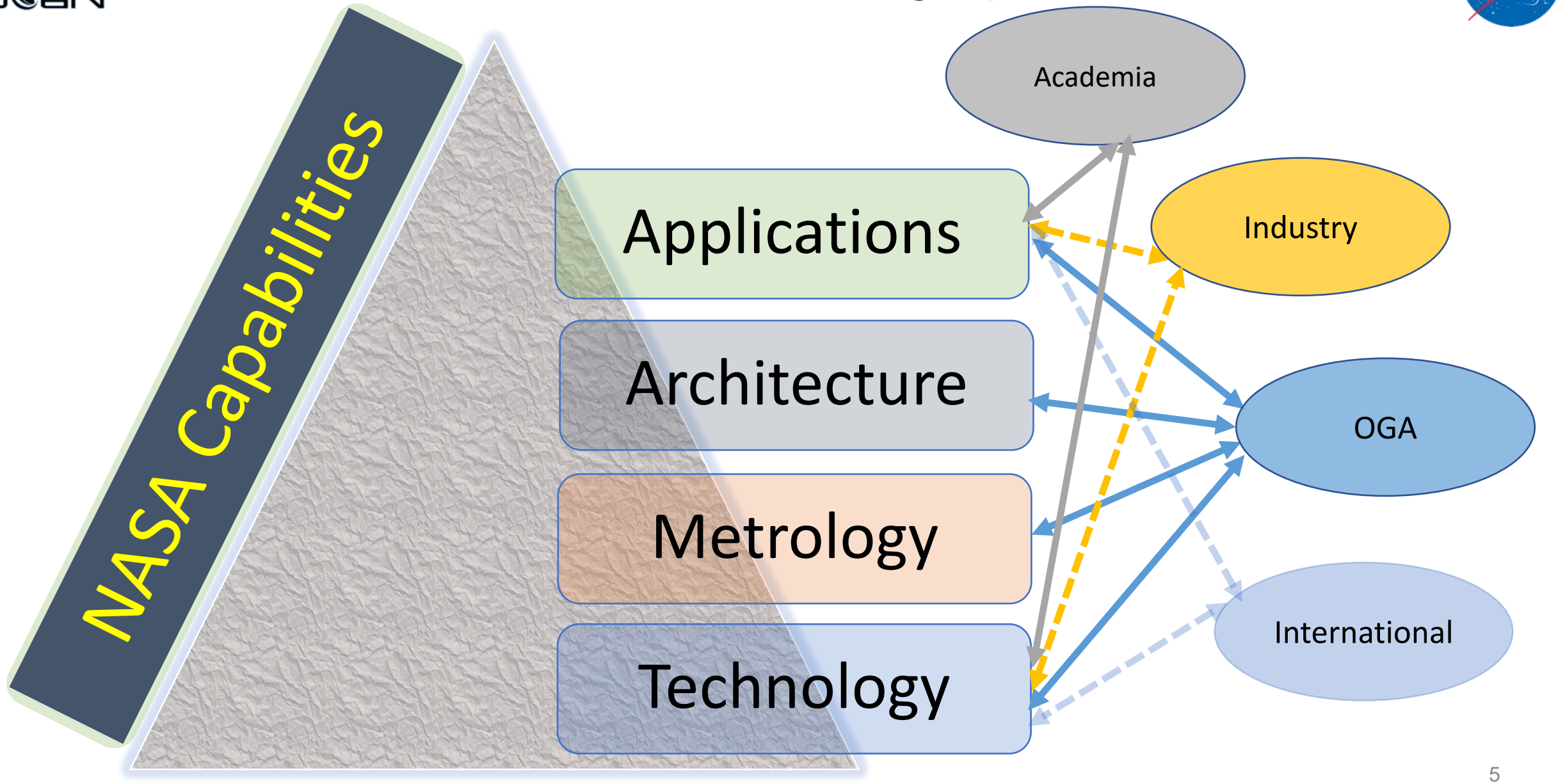
- Seek partners to leverage similar investments and goals

- Keep NASA at the forefront of emerging quantum tech/apps




- Active quantum STEM, training and workforce engagement

# The Vision: Develop NASA's space-based quantum communications and networking capabilities



# Space-Based Quantum Communications Testbed : QIS Benefits

- **Space-based testbed will be made available for US industry and academia to use to gain insights into key technology drivers and limitations of these systems (physical layer)**
  - Synchronization and Atmosphere impacts
  - Delays
  - Interfaces
- **System will serve as a platform for testing future free-space technologies and testing use cases**
- **Serve as bridge between regional quantum networks (can add ground stations)**
- **Industry will be involved in planning and execution of elements of both the space and ground systems building up expertise to be able to build future generations of systems**
  - Gimbals, spacecraft, ground telescope, etc.
- **Technology development spinoff: quantum memory and sources for terrestrial applications for quantum sensing, quantum computing, etc.**
  - Integrated optics solutions could be widely enabling

# Cross-cutting quantum technologies

## Quantum Sources

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## Quantum Detectors

Warm and cold
Space qualifiable

## Quantum Memory

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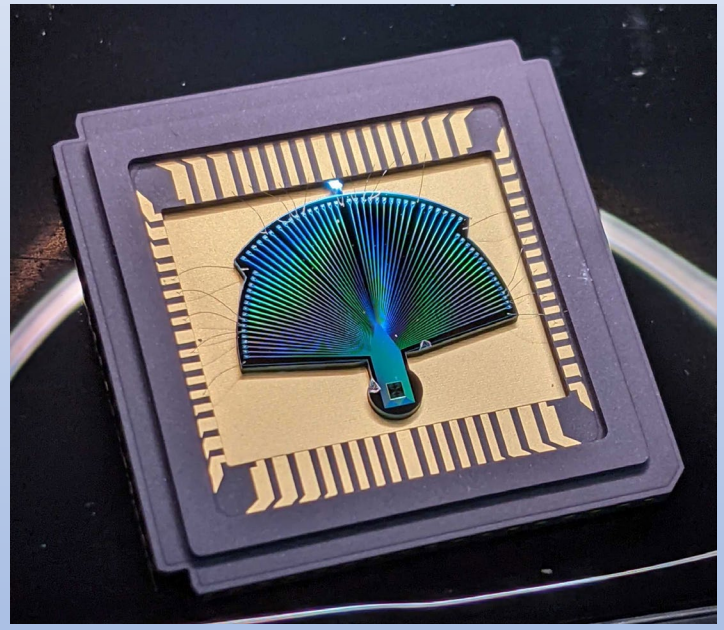


# Laser Communications Relay Demonstration (LCRD)

- LCRD showcases the unique capabilities of space-based optical communications
- Provides benefits for missions, including bandwidth increases of 10 to 100 times compared to RF systems
- Compared to RF, optical communications offer decreased size, weight, and power requirements, communications will supplement RF, giving missions unparalleled communications capabilities
- Invites users [?]


Laser Communications Relay Demonstration (LCRD) Overview - YouTube

# A vision for collaborative quantum comm R&D/T centers

- Partnership among industry, government, academia and state
- Led by industry
- Funding, administration, and management modality [under study]
- Timeframe: Within 3-5 years
- The need for a new partnership modality for Quantum 2.0



Lessons and guidance, e.g., *Government-Industry Partnerships for the Development of New Technologies*, edited by C. W. WESSNER, NRC (2003); http://nap.edu/10584

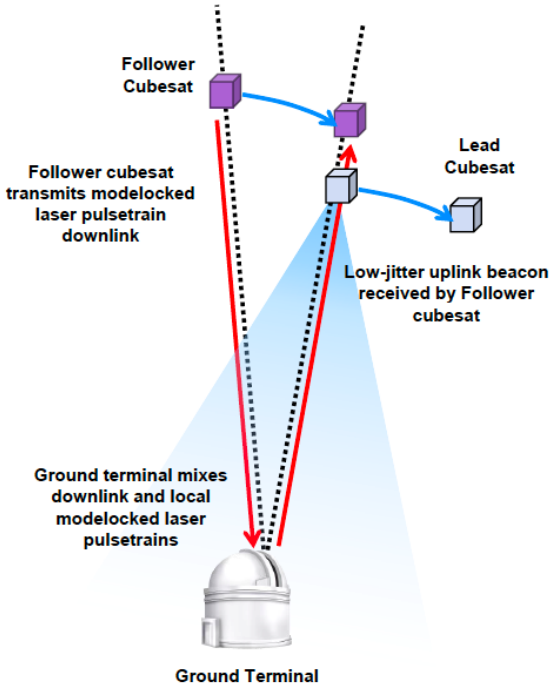
# Sample areas for potential collaboration

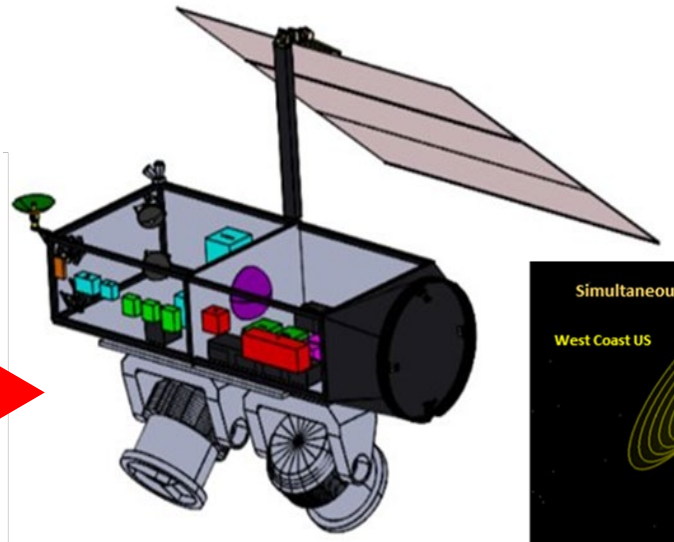
- Development of pre-competition (low TRL) technologies and applications
- Infrastructure building
- Testing and characterization at specialized facilities; components to systems
- Testing and validation using the new space-based testbed; new technologies (at the ground stations), new QIS protocols…
- Work force co-development and training; creation of specialized STEM programs at the local, state, and national levels

# Nominal Roadmap

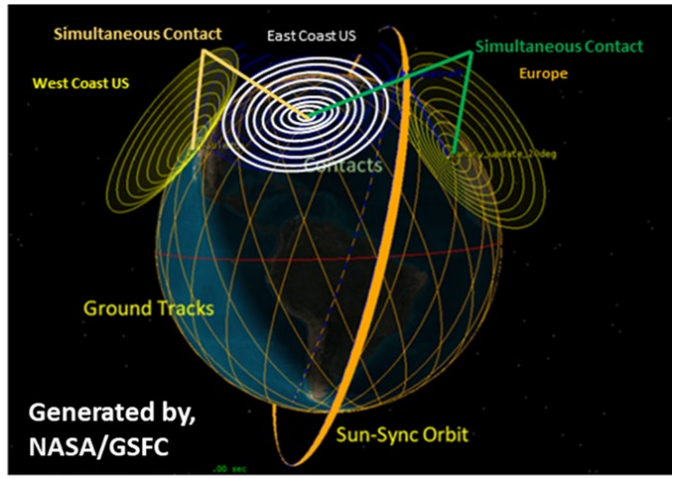
- First step is a 'warm' LEO testbed capable of ~100-Km Baseline - makes use of an uplink architecture that supports narrowband sources based on emission memory at 737nm and a wideband 780nm SPDC source, with BSM in Space
- Second step (M2.0) is optimized for 5000-Km (inter-continental), MEO, high performance

**LEO Testbed**
**Up to ~100s-Km Baseline**
**Warm (no Cryo), Uplink Only, ~0.8 telescope**



**MEO M2.0 MDL Study**
**Up to 5000Km Baseline**
**.8m telescopes, Cryo**

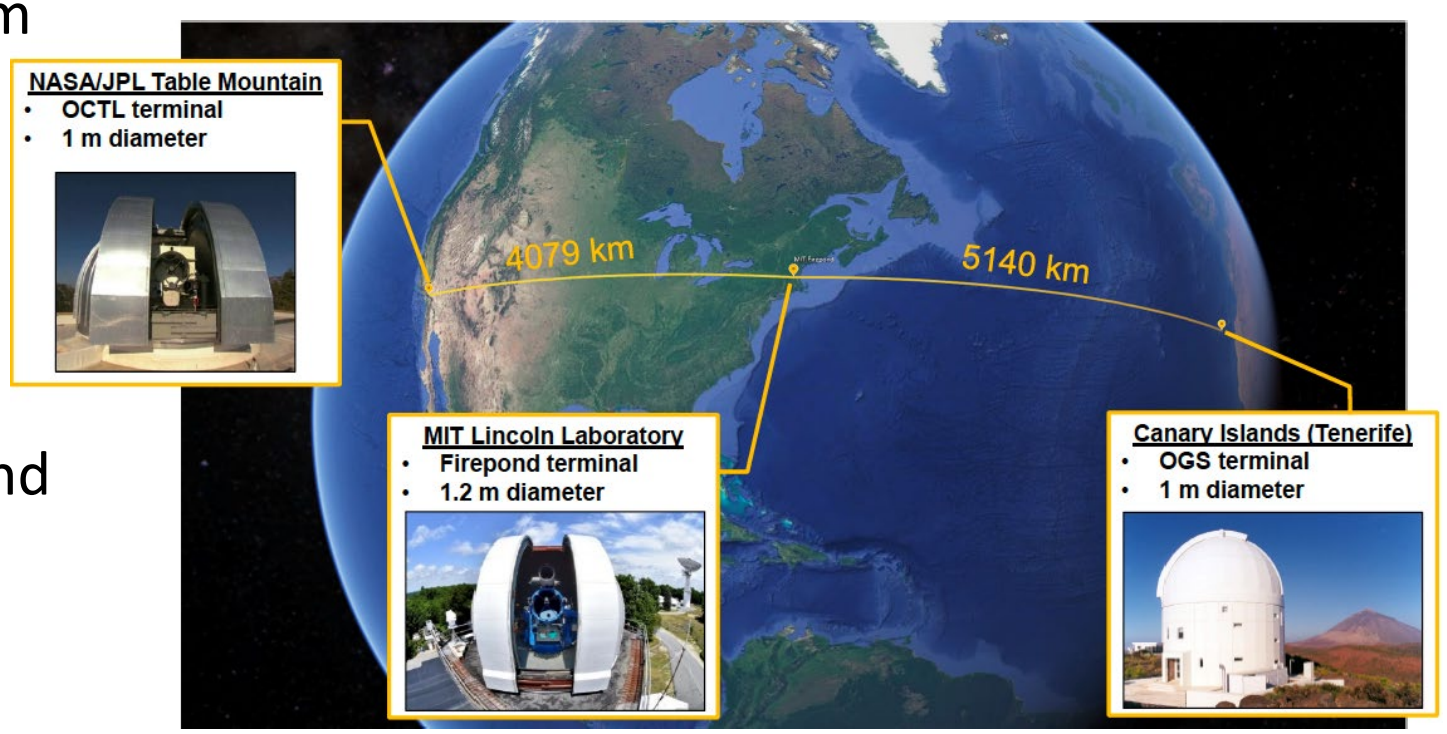



2026
Testbed in LEO

2031
M2.0 in MEO

# The vision: “M2.0”

- ✓ High-rate and high-fidelity quantum entanglement distribution capability across continental and trans-Atlantic/Pacific distances
- ✓ A unique and enabling space-ground platform for future space and terrestrial quantum networks
- ✓ The need for a space-based testbed




**Testbed will test and mature quantum technologies that thread many applications: from science, to computing, to networking and communications**

# SCaN HQ Quantum Team

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